Sodium-cooled Fast Reactor (SFR) Systems

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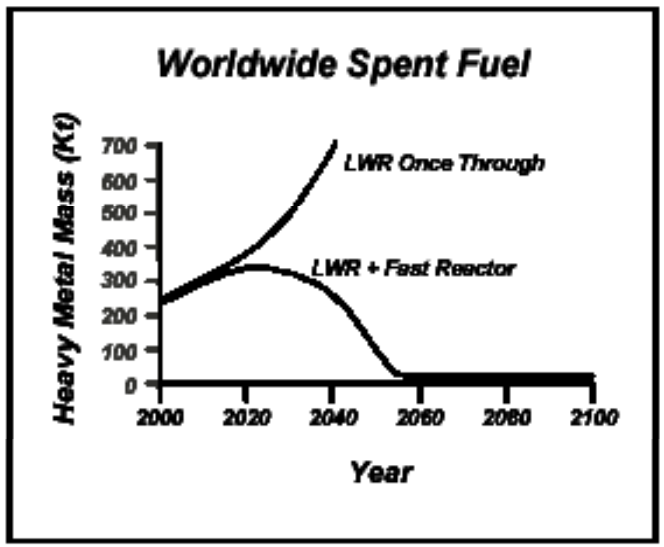
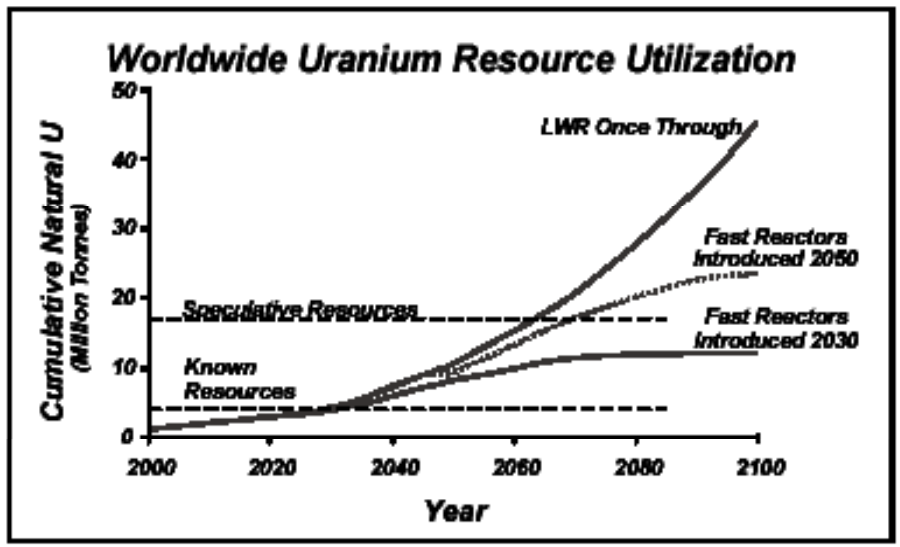
Concept Description

- *Sodium-cooled fast spectrum reactors using a closed fuel cycle with full actinide recycle*
- *Missions: Actinide management and electricity production*
  - » *Reduces physical demands on repositories*
  - » *Utilizes the entire natural resource of fissionable material*
- *Estimated Deployment Date: 2020*

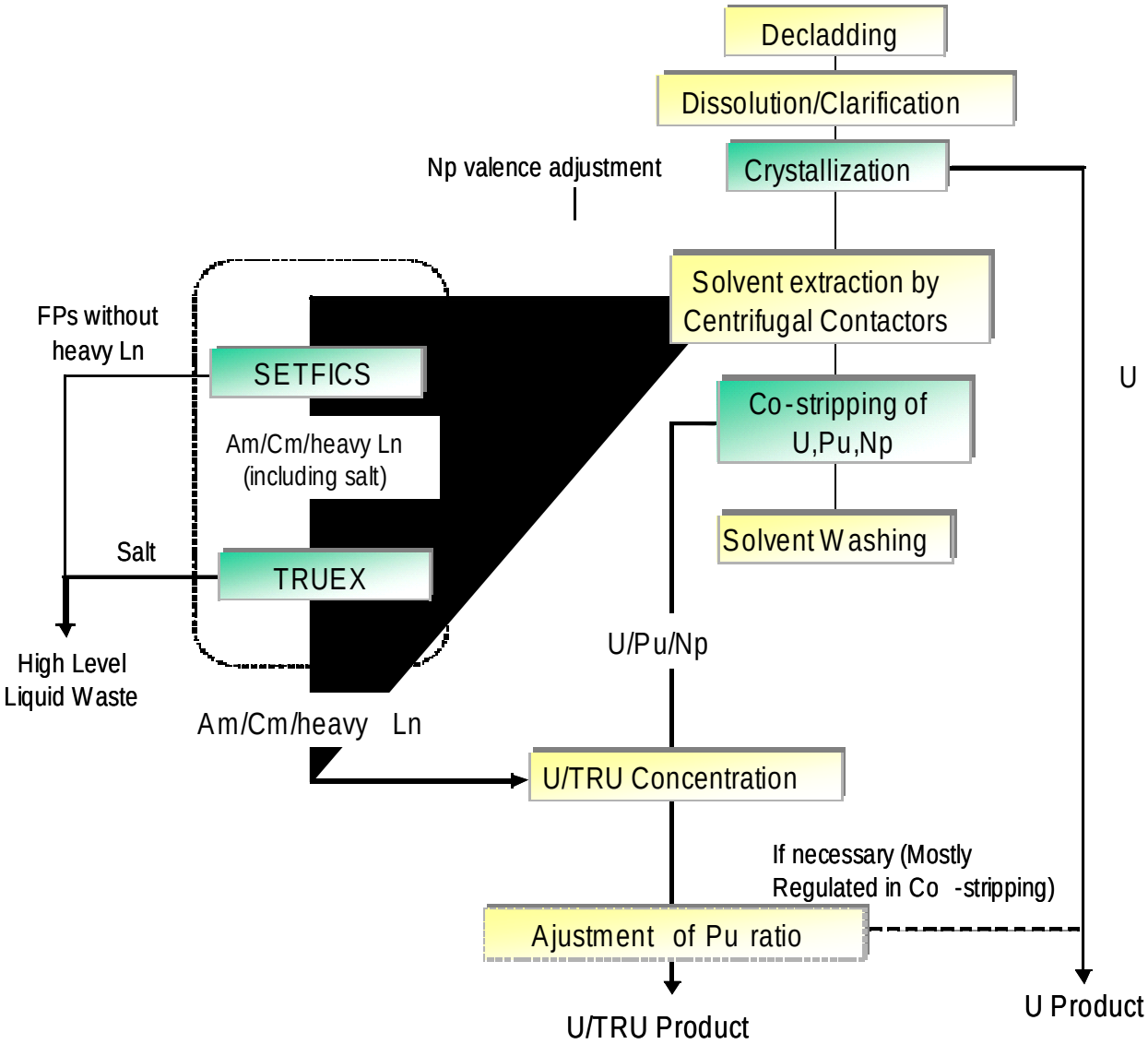




Fuel Cycle

- *Goals*
  - *Recovery and recycle of 99.9% of the actinides*
  - *Only trace amounts of fissile material to repository*
  - *Inherently low decontamination factor of the product (recovered actinides for recycle), making it highly radioactive*
  - *Never separating plutonium at any stage*
- *Fuel Options*
  - *Oxide*
  - *Metal*
- *Processing Options*
  - *Advanced Aqueous*
  - *Pyroprocessing*

Advanced Aqueous Technology



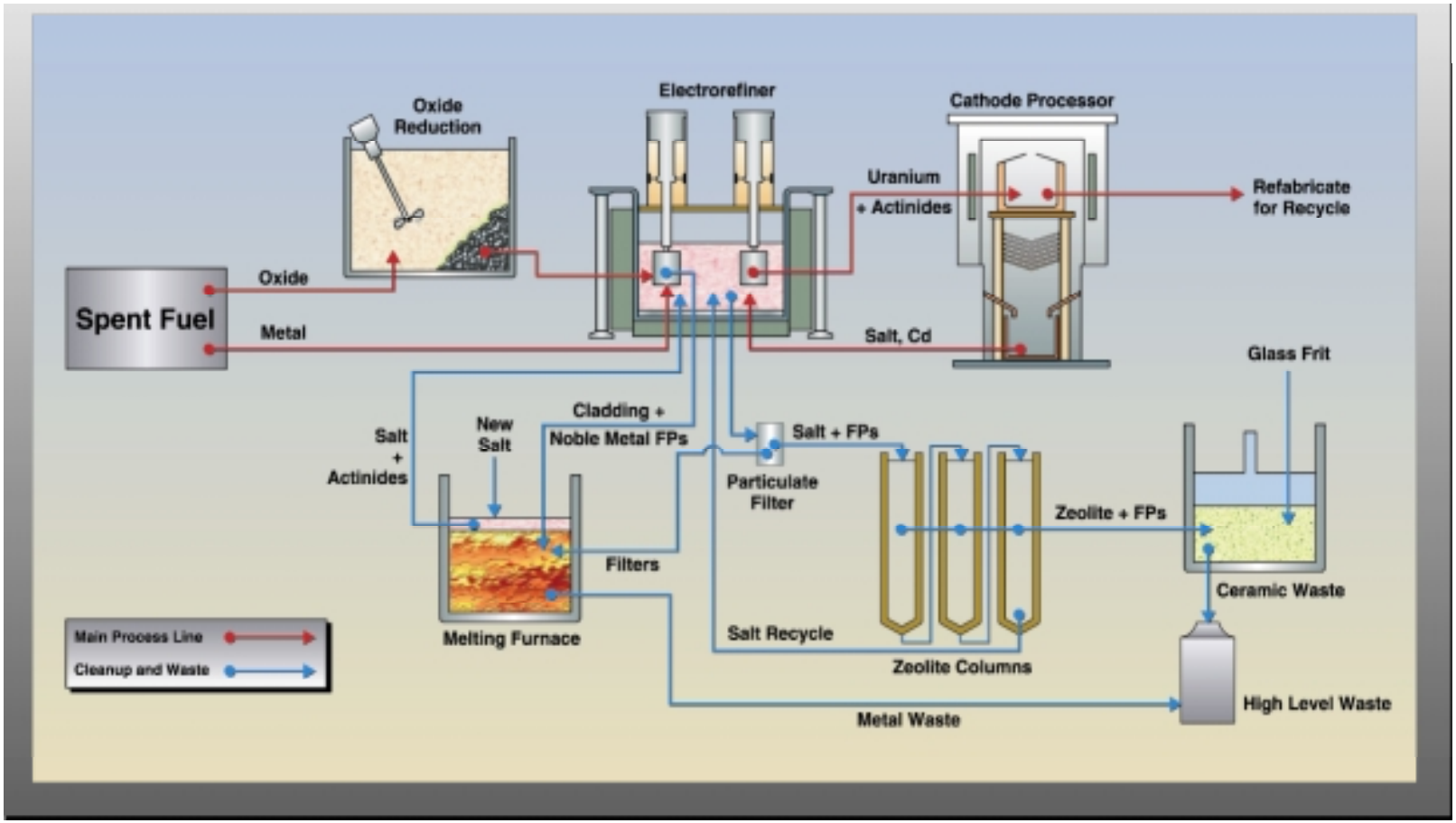
Uranium Crystallization - removes bulk of heavy metal

Uranium and Plutonium co-extracted with Np

Simplified pelletizing process

Waste form - vitrified glass

Pyroprocessing

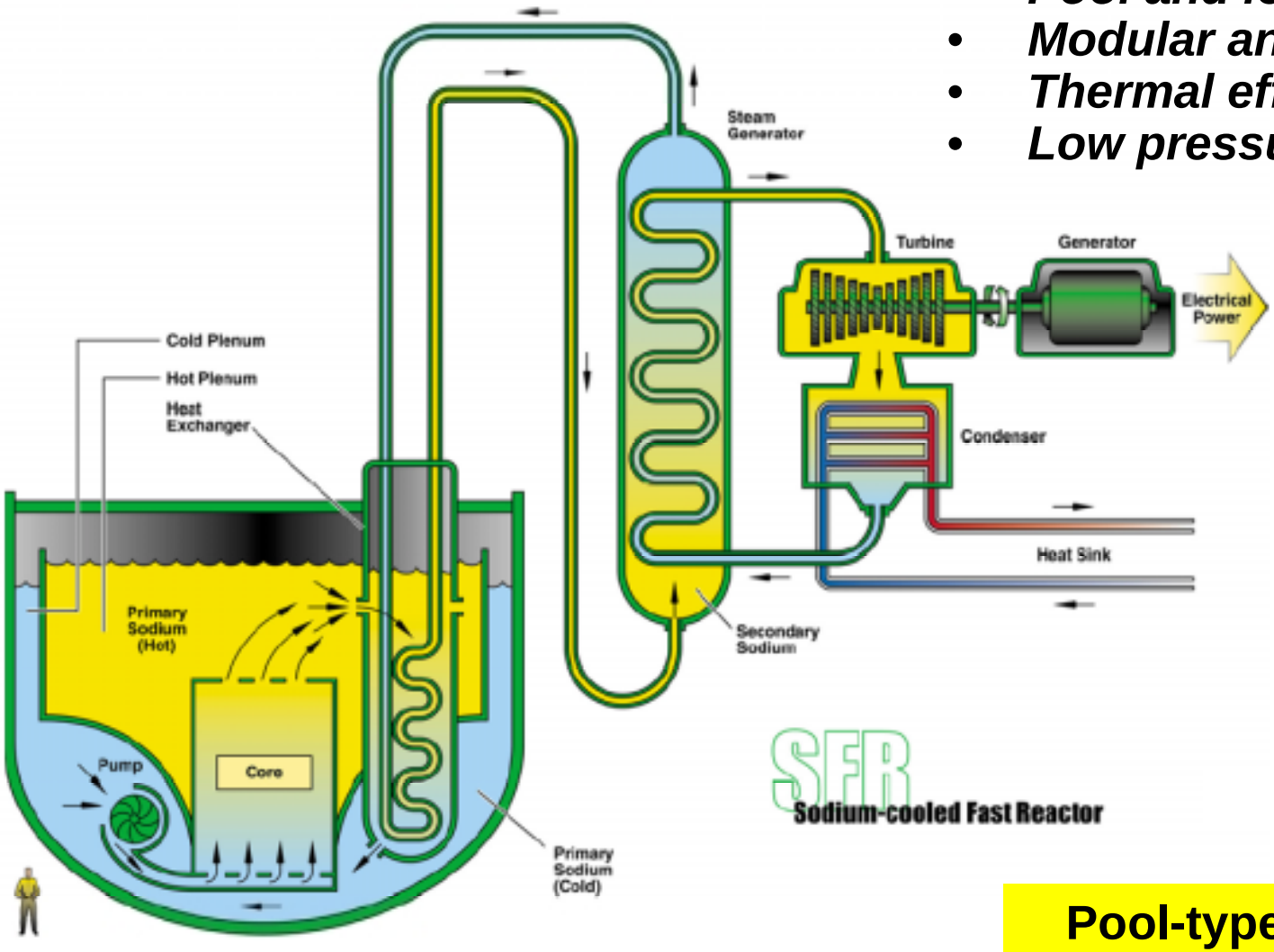


Plutonium and other transuranics carried with uranium

Metallic and ceramic waste forms

Sodium-cooled Fast Reactor (SFR)

- *Pool and loop designs*
- *Modular and monolithic designs*
- *Thermal efficiency about 40%*
- *Low pressure system*



Pool-type design example

Reactor

Benefits

- ***Safety case relies on passive response***
- ***Classical ATWS events cause no fuel damage***
- ***Decay heat removal system needs no forced circulation***
- ***Large thermal inertia***
- ***Large margins to boiling, low pressure, single phase phenomena***

Reactor Parameters	Reference Value
Outlet Temperature (^{o}C)	530-550
Pressure (Atmospheres)	~1
Rating (MWth)	1000-5000
Fuel	Oxide or metal alloy
Cladding	Ferritic or ODS ferritic
Average Burnup (MWd/kgHM)	~150-200
Conversion Ratio	0.5-1.30
Average Power Density	350 MWth/m^3

Major Research and Development Needs

Advanced Aqueous Fuel Cycle

- ***Crystallization performance of actinides and uranium, and the separation efficiency of solids at engineering scale***
- ***Develop the salt-free minor actinide recovery process with high extraction capability for Am and Cm, and separation from lanthanides***
- ***Develop compact centrifugal-type contactors to enable a reduction of the facility size***
- ***Establish the fabricability (in a hot cell facility) of low-decontamination factor minor actinide-bearing pellet fuel***
- ***Extend current studies of the proliferation resistance of this technology.***
- ***Comparison to other advanced aqueous process (e.g., UREX)***

Major Research and Development Needs

Pyroprocess Fuel Cycle

- ***Actinide recovery from spent thermal reactor fuel***
- ***Demonstration of plutonium and minor actinide extraction at larger scale***
- ***Minimization of secondary streams.***

General Fuel Cycle

- ***Adapt base advanced aqueous or pyroprocess front and back ends for use in conjunction with other fast spectrum Gen IV concepts (GFR, LFR, SCWR)***

Major Research and Development Needs

Fuel

- ***Further design base accident specific transient tests at high burnup***
- ***Irradiation and transient testing of recycled fuel fabricated with prototypic (remote) equipment***

Major Research and Development Needs

Reactor safety

- ***Demonstration of passive safety design: providing assurance that the physical phenomena and related design features relied upon to achieve passive safety are adequately characterized***
  - ***Axial fuel expansion and radial core expansion***
  - ***Self-activated shutdown systems***
  - ***Passive decay heat removal systems***
- ***Accommodation of extremely low probability but higher consequence accident scenarios***
  - ***Recriticality free systems that eliminate compaction-driven recriticality***
  - ***Coolability of debris remaining in the reactor vessel***

Major Research and Development Needs

Reactor Technology

- ***Improved Economics***
  - ***Design innovations (reduced loops, higher strength steels)***
  - ***Modularization***
  - ***Incorporating a Brayton cycle***
- ***In-service inspection and repair, leak detection.***

Implementation and concept studies

Conclusions

- *SFR has primary missions of actinide management and electricity production.*
- *Estimated deployment date: 2020*
- *Most direct path forward to implementing an effective actinide management strategy*
- *Development of engineering scale, proliferation resistant, fuel cycle is key*
- *Parallel reactor research is required to achieve required cost reductions and to place fuel cycle studies in context*